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Feature Article - Issues With Seasonal Adjustment of Hours Worked

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INTRODUCTION

The Australian Bureau of Statistics (ABS) estimates total hours worked for all Australian employed persons using the Labour Force Survey (LFS). In the LFS questions are asked about both the actual and usual numbers of hours worked by employed persons during the LFS reference week. In this article we consider issues relating to the seasonal adjustment of the National Accounts hours worked index series which is derived from the LFS actual hours worked estimates.

The hours worked estimate indexes published in the National Accounts are important indicators in their own right, but are also important in constructing indexes of output per hour worked (a form of labour productivity). These time series estimates are important in that they provide an understanding of how the economy is performing and they are also used in international comparison tables.

The ABS publishes seasonally adjusted time series on hours worked because these series are a more appropriate representation of the underlying change than the original series. They are adjusted for impacts due to systematic calendar variations. Ideally, all systematic calendar effects should be accounted for in the seasonal adjustment process. In particular, actual hours worked estimates need to be adjusted for the impact of holidays that overlap the LFS reference period.

In March quarter 2005, the National Accounts suspended publication of seasonally adjusted hours worked to enable the impact of holiday corrections to be assessed. The hours worked time series will be reintroduced for the June quarter 2005 National Accounts publication. A revised methodology for estimating holiday effect will be used for the series. This article provides a description of the revised methodology.

CONCEPTUAL ISSUES

The Labour Force Survey reference period usually occurs in the first two weeks of each month. Hours worked is recorded for the LFS reference period. This is effectively a stocktake of the hours worked at a specific point in time and cannot be used to directly measure working hours beyond the reference period. For example, estimating the hours worked in the first two weeks in December means we have never observed the working hours of Australian employed persons over the Christmas period.

The level of hours worked estimates, in original terms, may be misleading as the LFS reference period may contain a different amount of holiday time than would be expected for the remaining weeks in a particular month or quarter. Consequently the stock measure of hours worked

collected in the LFS reference period may not necessarily be representative of the entire month or quarter. To adjust for the impact of holidays, all holiday effects which can be estimated are removed from the hours worked series used in the National Accounts. Correcting for the impact of holidays which interact with the LFS reference period leads to seasonally adjusted hours worked estimates measured on a consistent level, with the impact of known holiday abstracted, over time. This can then be used to produce an appropriate index series of hours worked. The steps used to produce quarterly estimates for the National Accounts are:

- Holiday corrections are applied to the monthly hours worked estimates as collected in the Labour Force Survey.

- The monthly holiday corrected series is converted into a quarterly series by taking the mid-month of each quarter.

- The quarterly holiday corrected hours worked series is seasonally adjusted.

- A seasonally adjusted average hours worked estimate for the mid-month is derived by dividing the seasonally adjusted mid-month hours worked estimate by the seasonally adjusted mid-month employed estimate.

- The total hours worked for the quarter is derived by multiplying the seasonally adjusted average hours worked estimate for the mid-month by the average seasonally adjusted employment for the three months. This series is then converted into an index.

There are a number of additional adjustments made as part of the National Accounts to cater for remaining conceptual differences between the LFS and the National Accounts concepts of employment. For example, in the National Accounts measure of employment, defence force personnel are included and adjustments are made due to a change in the scope of the LFS in which unpaid family helpers working one to fourteen hours in the reference week were included in LFS employment estimates after 1986.

IMPROVING ESTIMATES OF HOLIDAYS

Seasonal adjustment is a process which estimates and removes systematic calendar related effects, s_t, from the original series, O_t, to give the seasonally adjusted estimates, $\widehat{SA}_t = O_t / \hat{S}_t$. As part of the seasonal adjustment process, known effects need to be estimated and removed prior to seasonal adjustment. These effects are called prior corrections. Intervention analysis is a technique used to identify the impact on a regular time series of certain known events. This technique is widely used in economic time series analysis. For example, Box and Tiao (1975), Tsay (1988), and Findley et al (1998) used this technique to identify outliers and calendar related effects for seasonal adjustment purposes. This process involves the design of an appropriate regressor to estimate a particular effect. For example,
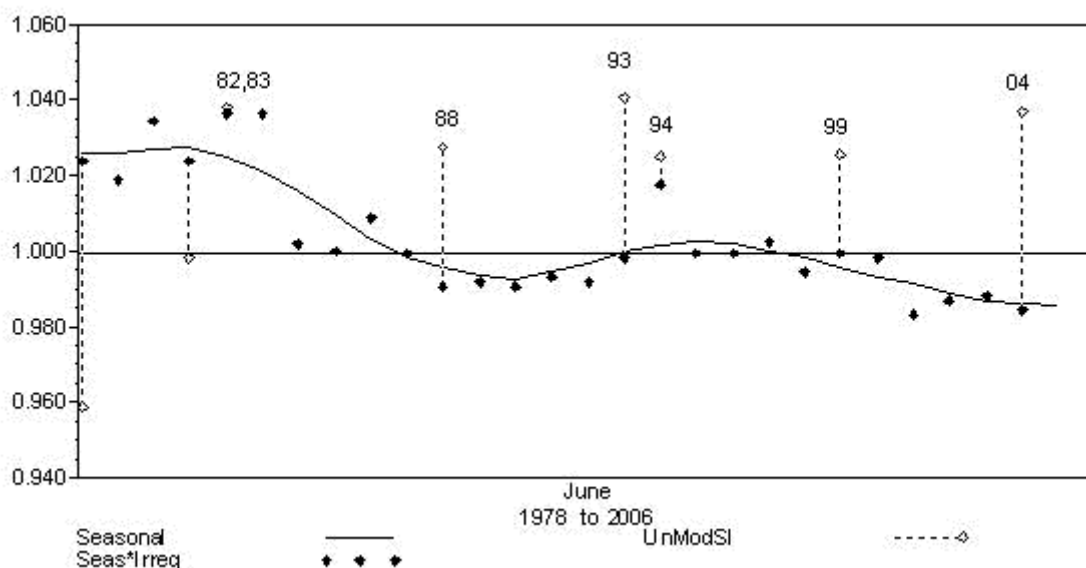
$$O_t = \sum_i \beta_i x_{it} + r_t$$

where, β_i are regression parameters estimated from the original estimates, x_{it} is a regressor designed to assess for a specific effect, and r_t describes the dynamics of the regular time series without the impact of particular events. Appropriate regressors can be designed to remove specific known impacts from the original estimates and improve the seasonally adjusted estimates. For example, effects such as public holidays, the starting date of the survey, use of supplementary surveys, and impacts of questionnaire redesign can be considered as measurement interventions to the "normal regular" hours worked time series, which should not contain effects due to the overlap of known holidays with the LFS reference period.

The aim of the holiday correction is to estimate and remove the holiday impacts prior to seasonal factor estimation. The resulting holiday corrected series will therefore be a series without known holiday impacts. This means that the seasonally adjusted holiday corrected series does not contain the impact induced from holidays as a part of calendar (seasonal) adjustment. The extent of the impact of a particular holiday will depend on how different persons are affected by that holiday. For example, there may be different reactions to specific holidays in different states, in metropolitan/ex-metropolitan areas and in different industries. For some holidays the effect may not be consistent from year to year due to factors such as the different dates of public holidays in different states.

A visual identification of the effect of holidays on hours worked is the seasonal x irregular chart (SI chart). SI charts are used to assess the seasonal x irregular components (SIs), used in the estimation of the seasonal factors, for a particular month or quarter. SIs are calculated by removing the trend estimate from the original series (for details see ABS, 2004). SI charts show the seasonal component as an unbroken line and the modified seasonal x irregular component as a set of filled points. The unmodified seasonal x irregular factors are included as the hollow points and are connected to the modified seasonal x irregular factors by a broken line. An example of the SI chart for hours worked in June is shown in Figure 1. The high values in 1982, 1983, 1988, 1993, 1994, 1999 and 2004 relate to months in which the Queen's Birthday public holiday did not overlap the Labour Force reference period. This shows a significant impact due to this public holiday on hours worked.

FIGURE 1: SEASONAL X IRREGULAR CHART FOR HOURS WORKED IN JUNE

WHAT HOLIDAYS HAVE A SIGNIFICANT IMPACT ON HOURS WORKED?

Previously, holiday correction factors were estimated based on a regression of the residuals after seasonal adjustment. This can result in biassed holiday correction factor estimates due to the effect of seasonal adjustment. The preferred approach is to estimate the holiday correction factors simultaneously as part of the seasonal adjustment process. This is the approach adopted in Regression-ARIMA intervention analysis.

To adjust for the impact of holidays on the hours worked estimates a range of appropriate regressors were developed and assessed individually. Each of the regressors was examined in detail and determined to adjust for a specific holiday affecting the hours worked series. Estimated correction factors were found to be statistically significant for the following holiday impacts: Easter, start date of the LFS in January, Queen's Birthday, Australia Day, and School holidays in particular months.

In practice, all holidays impacting the hours worked series cannot be considered individually. For example, if an employed person does not work any hours on the New Year's day public holiday they will not work any less hours on this day if it is also a school holiday. The regressors identified in Table 1 must be considered together to determine their combined significance. All regressors identified in Table 1 were still significant.

TABLE 1. SIGNIFICANT HOLIDAY REGRESSORS ON HOURS WORKED ESTIMATES

Holiday	Regressor	Parameter estimate (percentage impact)	t-statistic
Easter overlap with LFS reference period	Easter Monday	-11.9%	-33.2
	Easter Monday, Good Friday	-18.8%	-48.1
	Good Friday	-6.5%	-15.5
January start date of Labour Force Survey	New year's day	-7.1%	-13.2
	Summer holiday	-1.6%	-11.9
Queen's birthday	June	-4.2%	-12.1
Australia day	February	-6.3%	-14.2
School holidays	October	-8.2%	-10.6
	September	-8.8%	-7.4
	May	-6.6%	-5.2
	July	-4.0%	-4.3

Note: If the absolute value of the t-statistic is higher than a critical value of approximately 2.0 then this effect is statistically significant (at the 95% level) relative to the variation expected of such estimates.

Figure 2 shows boxplots of the irregular component after seasonal adjustment for the monthly time series for the previous holiday corrections and the proposed holiday corrections grouped by month. Boxplots can be used to show the location and spread of the data and to indicate any extreme points (highlighted as circles outside the box). The median of the data is presented as a straight line within the box while the box shows the limits of the middle half of the data. Figure 2 shows that the volatility of the irregulars of each month is reduced with the implementation of the new holiday corrections. This is especially clear in the months of January and April which are affected by the January start date of the LFS and Easter holidays respectively.

Quality measures can also be used to show that the use of the regressors improved the quality of the series. For example, the Average Absolute Percentage Change (AAPC) of the estimates under the two different approaches can be calculated. A large number for the AAPC will indicate a high level of volatility. Table 2 shows the AAPC values for the original, trend and irregular estimates. The larger the AAPC for the irregular, the more the irregular component is likely to dominate movements in the seasonally adjusted series, which implies greater revisions to the seasonally adjusted and trend series. Table 2 illustrates that the proposed holiday corrections applied to the monthly time series for hours worked results in considerably reduced volatility for the monthly estimates.

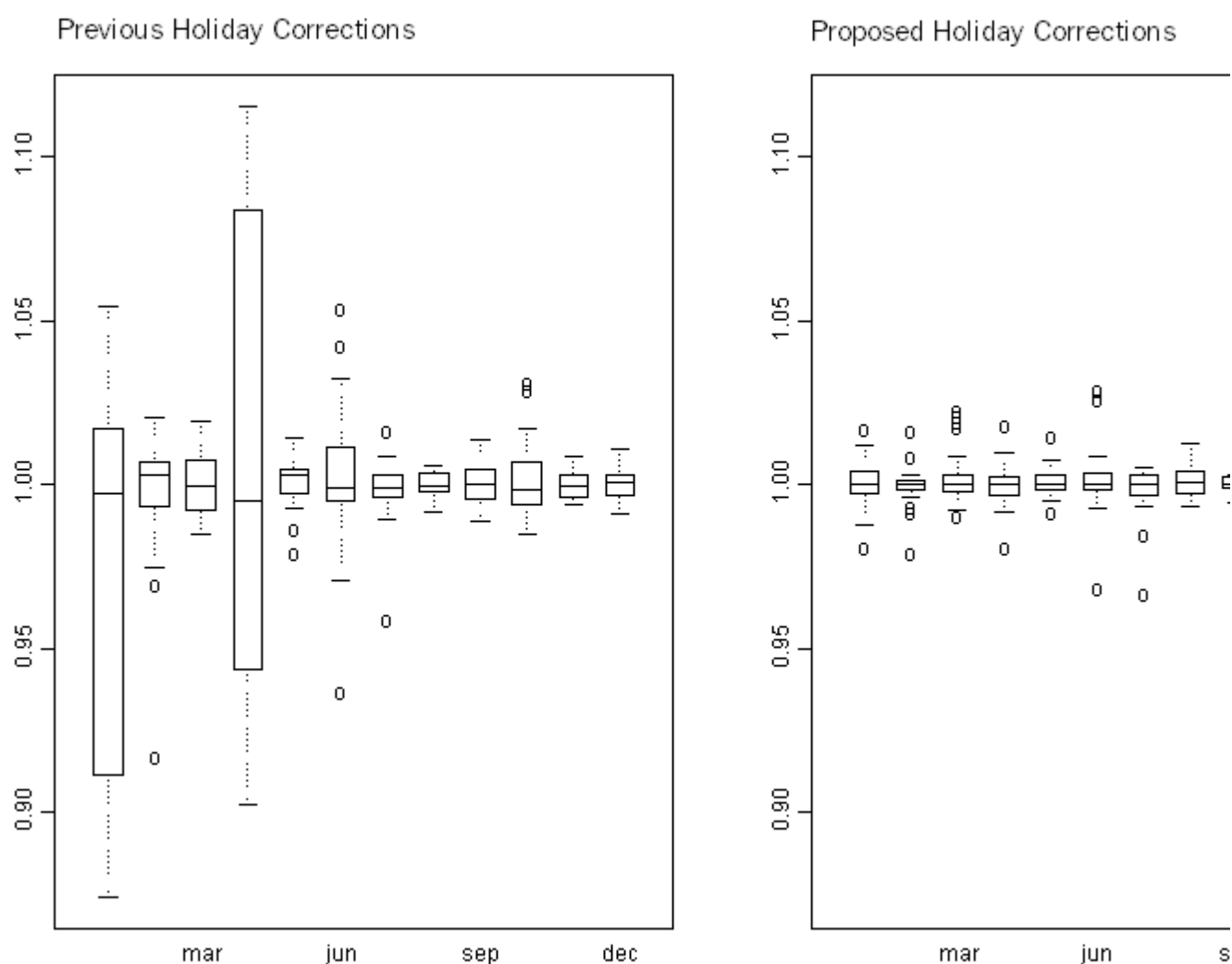## FIGURE 2: BOXPLOTS COMPARING VOLATILITY IN MONTHS PREVIOUS AND PROPOSED HOLIDAY CORRECTIONS

Previous Holiday Corrections — Proposed Holiday Corrections

TABLE 2. AVERAGE ABSOLUTE PERCENTAGE CHANGE (AAPC) COMPARISON OF PREVIOUS AND PROPOSED HOLIDAY CORRECTED ESTIMATES

Estimate	AAPC: Previous holiday corrections	AAPC: Proposed holiday corrections
Original	7.99	4.87
Irregular	2.54	0.62
Trend	0.25	0.22

CONSTRUCTING A QUARTERLY HOURS WORKED SERIES

The monthly holiday corrected time series needs to be converted to a quarterly time series for use within the National Accounts. A range of methods are available.

These include:

- Take the middle month of each quarter as representative of the entire quarter. For example, the February estimate can be used as an estimate of the entire March quarter, including appropriate adjustments. This is referred to as the mid-month method. Seasonal adjustment is then performed on these quarterly estimates.
- Take the mean of all three months in each quarter. For example take the mean of the January, February and March estimates as the March quarter estimate. This is referred to

as the mean of three method. This quarterly series can then be seasonally adjusted.

- Seasonally adjust the monthly time series and then aggregate to a quarterly time series using the mid-month method.

- Seasonally adjust the monthly time series and then aggregate to a quarterly time series using the mean of three method.

The appropriateness of these methods is the subject of continued evaluation. The previously used method is a mid-month method. This method is consistent with market sector hours worked estimates which are only available for the middle month of each quarter from the LFS.

COMPARING THE PREVIOUS SEASONALLY ADJUSTED ESTIMATES WITH THE PROPOSED ESTIMATES

We now compare the proposed seasonally adjusted estimates based on the updated holiday corrections with the previous seasonally adjusted estimates. Both approaches use a mid-month method.

Figure 3 shows boxplots of the irregular component after seasonal adjustment under the two approaches. This shows that there is not much difference in the distribution of the irregular component between the proposed approach and the previous approach. That is, the approach of using the updated holiday corrections produces a quarterly seasonally adjusted hours worked series that has similar overall volatility, as measured by the AAPC of the irregular, to the previous approach in all quarters. This was expected, as most holidays do not affect the mid-month of the quarter and consequently the proposed and previous holiday corrected mid-month series are similar (The porposed holiday corrections had most impact in January, April, June and October which are not mid-months in the quarter). The volatility in March and December quarters has been reduced substantially using the proposed method although the previous method appears less volatile in the September quarter. There are fewer values identified as extreme under the proposed approach.

FIGURE 3: BOXPLOTS OF THE IRREGULAR COMPONENT COMPARING VOLATILITY BY QUARTER OF PREVIOUS AND PROPOSED SEASONAL ADJUSTMENT METHODOLOGIES

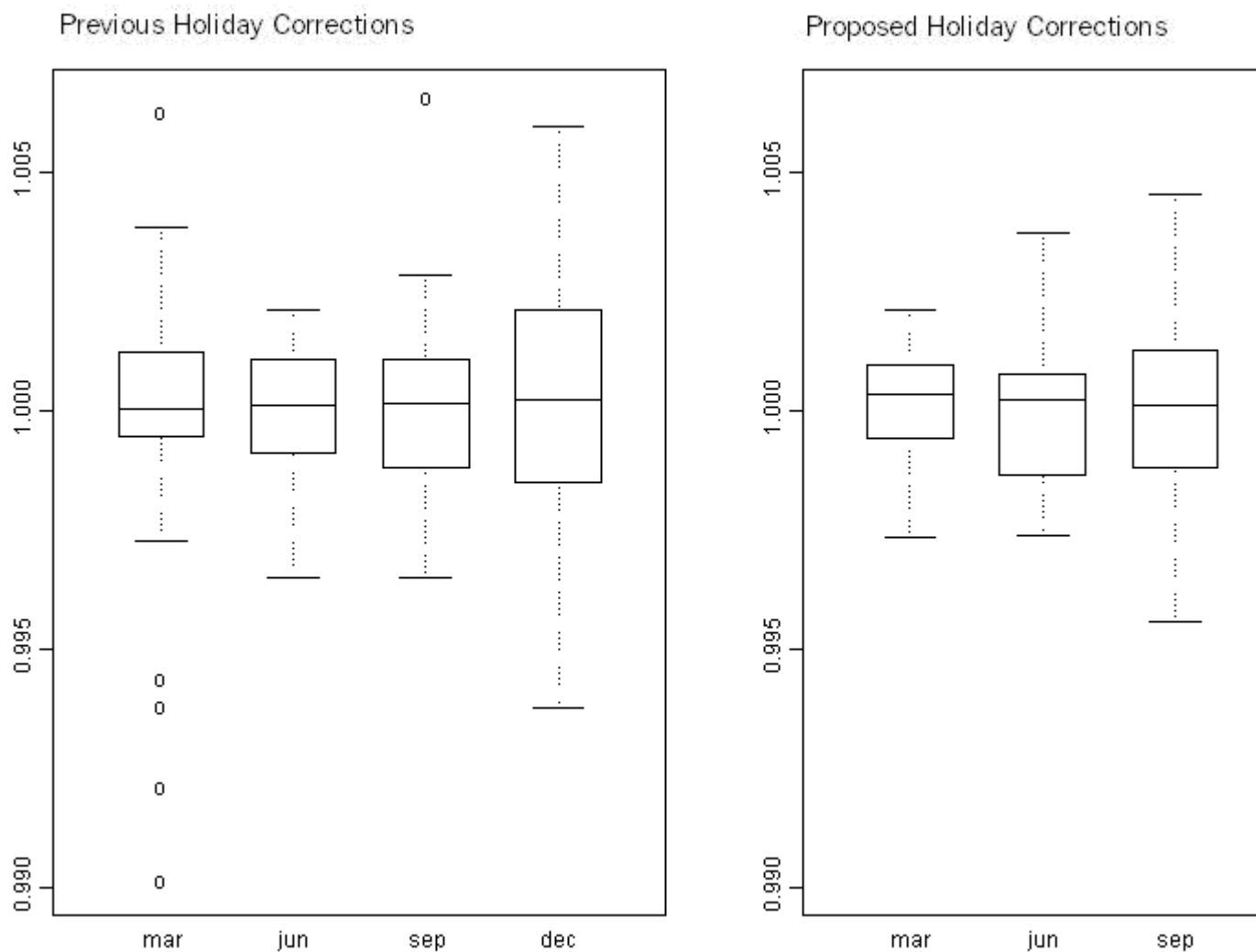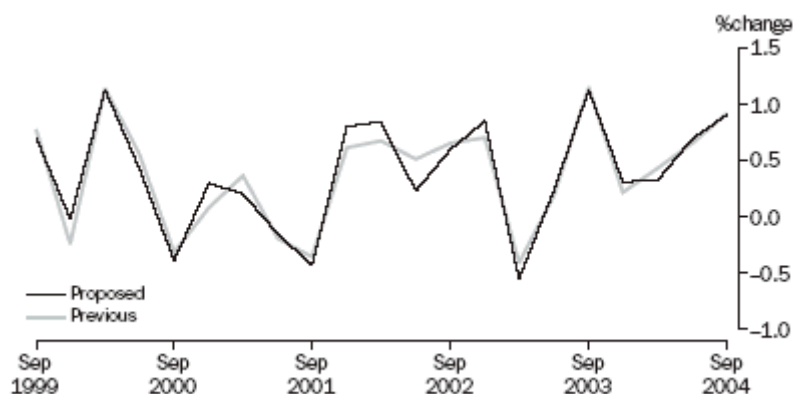Previous Holiday Corrections   Proposed Holiday Corrections

Figure 4 shows a comparison over the last five years of quarterly movements in the seasonally adjusted estimates. The seasonally adjusted movements for both approaches are very similar. For example, the percentage movements for both approaches are: 0.9% for September quarter 2004 and 0.7% for June quarter 2004, while they are 0.4% and 0.3% for March quarter 2004 for the previous and proposed approaches respectively. The seasonally adjusted estimates are revised as additional original estimates become available. The seasonally adjusted movement estimates may differ from those published in the National Accounts as they have been calculated without the impact of post-seasonal adjustment National Accounts additions such as the inclusion of defence force personnel. Figure 4 provides an indication of the impact of the previous and proposed holiday correction factors on quarterly seasonally adjusted hours worked estimates. The June quarter 2005 National Accounts publication will contain estimates of movements in seasonally adjusted hours worked, based on the proposed methodology for all periods up to June quarter 2005.

FIGURE 4: PERCENTAGE MOVEMENTS IN SEASONALLY ADJUSTED ESTIMATES FOR HOURS WORKED UNDER PREVIOUS AND PROPOSED APPROACHES

LEVELS OF HOURS WORKED AND PRODUCTIVITY

The proposed methodology is considered to provide an acceptable measure of movements in hours worked, but it does not provide an appropriate measure of levels of hours actually worked. This is because;

- the impact of certain holidays in the LFS period is removed in the calculation, and

- no attempt is made to take account of holidays outside the LFS period.

It is assumed that the impact of these two factors would have only a negligible impact on the seasonally adjusted movement estimates. The ABS is investigating how an appropriate measure of actual hours worked can be compiled to take account of the second factor.

As the proposed methodology does not provide an appropriate measure of the level of hours actually worked, the series will only be presented in the form of an index (as was the case with the previous series).

The proposed methodology can be used to construct estimates of movements in output per hour worked, which is a measure of labour productivity. These series are also presented in index form. However, it cannot be used to construct estimates of levels of output per hour worked; for example, to compare Australia with other countries. To do so requires an appropriate measure of the level of hours actually worked which includes the impact of holidays. As there are relatively less holidays in mid-months, this would have the impact of reducing estimates of hours worked.

CONCLUSION

The holiday correction factors have been improved for the seasonal adjustment of hours worked for use as an index within the National Accounts. A regression-ARIMA intervention analysis methodology (Findley et al, 1998) was applied to produce updated holiday correction factors which can be applied to and removed from the original hours worked estimates for the purpose of seasonal adjustment and constructing an index.

The approach of using the updated holiday corrections produces seasonally adjusted quarterly hours worked estimates that are similar, in terms of volatility and movements, to the previous production method. This is expected, as most holidays do not affect the mid-month of the quarter and consequently the mid-month seasonally adjusted estimates were not being significantly affected by previous inappropriate holiday correction factors.

This article has concentrated on the seasonal adjustment of hours worked for use as an index in

the National Accounts. Further work is underway to consider alternative ways to construct quarterly time series estimates of hours worked that will provide appropriate measures of the level of hours actually worked, taking into account the real impact of the holiday pattens of employed Australians.

FURTHER INFORMATION

Further information about detailed holiday correction method can be obtained by contacting Nick von Sanden on 02 6252 7368 or fax 02 6252 8015, or email <nick.von.sanden@abs.gov.au>.

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